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13. ABSTRACT (Maximum 200 words)

The underlying technology for THz polaritonics – programmable, solid-state, THz-bandwidth signal processing – was developed. Two primary steps enabled this achievement. First, an automated spatiotemporal femtosecond pulse shaping system, through which ultrafast laser pulses could be directed at specified times to specified locations (i. e. to specified addresses), was created. Second, the system was applied to spatiotemporal coherent control over THz-frequency polariton waves (which serve as ultrahigh-bandwidth signals) in crystalline solids. The methods open the way to a versatile electro-optic signal processing platform in which the THz-bandwidth signals are generated, propagated, manipulated, and read out, all without loss of bandwidth. The results of this project have spawned numerous further refinements of polaritonics technology as well as advances toward fundamental and practical applications.

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COHERENT CONTROL OVER EXCITATIONS AND SIGNALS IN SEMICONDUCTORS
Grant No. DAAG55-98-1-0431

FINAL REPORT
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Problem Studied and Principle Results

In this project, entirely novel methods were developed for generation, manipulation, and detection of THz frequency, THz bandwidth lattice waves in semiconductors. Coherent control over mixed lattice vibrations and electromagnetic waves called phonon-polaritons, or simply polaritons, was made possible through these developments. The methods open the way to a versatile THz-bandwidth signal processing system.

First, a fully automated method for high-fidelity *spatiotemporal femtosecond pulse shaping* was developed. In this method, a single input laser beam with a single ultrashort pulse is transformed into many output beams, each of which has an independently specified pulse sequence or other time-dependent optical waveform. The output beams can be directed to different regions of a sample – i.e. different addresses on a device – for generation and control over polariton waves. In this manner, *spatiotemporal coherent control* over THz signals is achieved.

These developments have led the way to the dawn of *polaritonics* – fully programmable, THz-bandwidth solid-state signal processing and control. Further work during the current grant period has demonstrated the versatility and potential of the polaritonics for fundamental and practical applications.

Publications

(a) peer-reviewed journals

“Terahertz polaritonics: Automated spatiotemporal control over propagating lattice waves,” R. M. Koehl and K. A. Nelson, Chem. Phys. **267**, 151-159 (2001).

(b) conference proceedings

“Spatiotemporal coherent control,” R. M. Koehl and K. A. Nelson, in Ultrafast Phenomena XII , T. Elsaesser, S. Mukamel, M. M. Murnane, and N. F. Scherer, eds. (Springer-Verlag ser. Chem. Phys. v. 66, 2001), pp. 36-38.

(c) conference presentations (no proceedings)

Note: this is a partial list of invited talks only

Optimal Control of Quantum Dynamics: Theory and Experiment, 9-14 December 2001, Tegernsee, Germany

IEEE Lasers & Electro-Optics Society Meeting, 11-15 November 2001, San Diego, CA

5th Femtochemistry Conference, 2-6 Sept. 2001, Toledo, Spain

Gordon Research Conference on Coherent Control or Atomic and Molecular Motion, 29 July – 3 August 2001, Mount Holyoke, Massachusetts

The second RIES-Hokudai Symposium, 8-9 March 2001, Sapporo, Japan

Fundamental Physics of Ferroelectrics, 13-20 Feb. 2001, Aspen, CO

Ultrafast Processes in Physical Chemistry, 3-8 Sept. 2000, Champery, Switzerland

American Chemical Society Meeting, Symposium on Quantum Computing for the Next Millennium, 20-24 August 2000, Washington, D.C.

International Workshop on Optical Control of Quantum Dynamics: Theory and Experiment, 25-27 July 1999, Tegernsee, Germany

4th Gordon Research Conference on Photoacoustic and Photothermal Phenomena, 27 June – 2 July 1999, New London, NH

Participating Scientific Personnel

Timothy Crimmins, Ph.D., 1999

Richard Koehl, Ph.D., 1999

Michael Gleason, M.S., 2001

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Nikolay Stoyanov, current Graduate Student